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AUTHOR Baker, Linda; Anderson, Richard I.
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ABSTRACT

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CENTER FOR THE STUDY OF READING

Technical Report No. 203

EFFECTS OF INCONSISTENT INFORMATION ON TEXT PROCESSING: EVIDENCE FOR COMPREHENSION MONITORING

Linda Baker
University of Maryland
Baltimore County

Richard I. Anderson
University of Illinois
at Urbana-Champaign

May 1981

University of Illinois
at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02238

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Abstract

Expository passages containing either main point inconsistencies, detail inconsistencies, or no inconsistencies were presented sentence by sentence to 90 college students. Subjects read through the passages at their own pace and were encouraged to reread previous sections of text whenever they wished. As expected, subjects spent more time on sentences containing information that conflicted with information presented elsewhere, and they looked back more often at inconsistent sentences. These modifications in processing indicate that the subjects monitored their comprehension as they were reading, actively evaluating whether the ideas expressed in the text were consistent with one another. Several postreading measures provided additional support for this conclusion. The relationship between reading behavior and subsequent identification of the inconsistencies was also examined. Large individual differences were found both in processing strategies and in confusion detection.

Effects of Inconsistent Information on Text Processing: Evidence for Comprehension Monitoring

The continuing surge of interest in the cognitive processes involved in comprehension has given rise to a new domain of inquiry: the role of metacognition in comprehension (Baker, 1979c; Baker & Brown, in press; Brown, 1980; Flavell, in press; Markman, in press). Metacognition refers to one's knowledge and control of his own cognitive processes (Flavell, 1978). The metacognitive activities involved in comprehension include keeping track of the success with which one's comprehension is proceeding and ensuring that the process continues smoothly by taking remedial action if comprehension falters.

It has long been argued that these monitoring activities are crucial to effective reading (Dewey, 1910; Huey, 1908/1968; Thorndike, 1917), and many recent theories of comprehension incorporate monitoring components into their models (e.g., Collins, Brown, & Larkin, 1980; Goodman, 1976; Just & Carpenter, 1980; Ruddell, 1976; Rumelhart, 1980). We now have ample evidence that beginning and less able readers appear to be deficient at evaluating their understanding of text (Baker & Brown, in press; Di Vesta, Hayward, & Orlando, 1979; Garner, 1980; Markman, 1979; Winograd & Johnston, 1980; Forrest & Waller, Note 1; Paris & Myers, Note 2), but there have been few empirical tests of the crucial assumption that mature readers do monitor their comprehension effectively. Baker (1979a) conducted a preliminary study to ascertain whether this assumption is warranted. The study employed a "disruption" paradigm (Markman, 1977; Miller & Isakson,

1978), wherein confusing elements are deliberately introduced into a text and failures to notice the disruptions are taken as evidence of ineffective comprehension monitoring.

College students were presented with six expository passages, each containing either an inappropriate logical connective, an ambiguous referent, or an inconsistent fact. They were instructed to read the passages carefully in preparation for subsequent "discussion" questions without being told that disruptions were present. After reading, the subjects answered questions requiring recall of the deficient sections of text. The purpose of the recall task was to reveal whether subjects modified the disruptions in some way to render them more sensible. Next, subjects were informed that the paragraphs did, indeed, contain confusing sections and were asked to identify them, rereading the paragraphs if necessary. The subjects were also asked to comment retrospectively on how they had reacted to the confusions when they were first encountered and how the confusions had affected their understanding of the passage.

Across all subjects and passages, only 38% of the confusions were correctly identified. Though this figure suggests that subjects were poor at monitoring their comprehension, the recall protocols and retrospective reports revealed otherwise. The subjects had a wide repertoire of strategies available for dealing with the confusing sections of the text. (See Baker, 1979b, for a detailed discussion of these strategies.) For example, they made inferences that resolved the confusions, they reread the passage or looked ahead in search of clarification, they decided the confusions were

too trivial to attempt to resolve, or they assigned an interpretation to the text that differed from the intended meaning. In short, most students apparently did evaluate and regulate their understanding, even if they did not perceive the intended disruptions as such.

One limitation of the Baker (1979a) study is that it relies on data obtained after reading to make inferences about events occurring during reading (Ryan, in press; Simons, 1971). The evidence for ongoing comprehension monitoring would be more compelling if we found on-line modifications in text processing due to the presence of a disruption. The present study was designed in an effort to provide such evidence.

Passages were presented on a computer terminal, sentence by sentence, under the individual reader's control. Subjects advanced to subsequent sentences at their own pace and were encouraged to look back at previous sentences whenever they wished. The computer automatically recorded the amount of time each sentence was exposed and the pattern of movement through the text. Each subject read three experimental passages, one with an inconsistent main idea, one with an inconsistent detail, and one with no inconsistency. It was expected that subjects would spend more time reading a particular sentence when it contained information inconsistent with the passage than when it was consistent. It was also expected that subjects would look back more often at the inconsistent sentences in an effort to resolve or verify the problem. After reading each passage, subjects were asked to answer several multiple choice questions in order to reveal how the inconsistent information had been interpreted. Finally, confusion detection was assessed directly by asking subjects to indicate which

sentence, if any, contained an inconsistency and to report whether they noticed the problem during their initial reading of the passage.

Prior to reading, half of the subjects were informed that inconsistent information would be present and that they would be asked to identify the inconsistencies later. Alerting the subjects in this way should put them in an editorial processing mode, thereby increasing the amount of time spent on the passages and increasing the likelihood of noticing the inconsistencies during reading.

A secondary goal of the present study was to attempt to develop a profile of the successful comprehension monitor. Although our subject population is comprised of individuals who read at or near college level, there are undoubtedly large individual differences in their reading proficiency. Therefore, we expect that some students will be more sensitive to the inconsistencies than others. The question of interest is whether there are specific processing activities characteristic of subjects who subsequently report the inconsistencies that are not characteristic of the nondetecting subjects.

Method

Materials

The materials consisted of four three-paragraph passages that dealt with topics in world history. The passages, written by the experimenters, were based on Cliff's Course Outline in World Civilization (Leon, 1970). Each of the three paragraphs in a passage focused on a separate aspect of

the main topic. For example, in a passage about the Moslem civilization, the first paragraph dealt with the social structure, the second with the economy, and the third with the culture. One of the four passages served as a warm-up passage and always appeared in its original form. The middle paragraph of each of the remaining passages was modified to contain inconsistencies involving the main idea of the paragraph and a detail. Only one of these inconsistencies appeared in a given passage at one time. The inconsistencies were created by replacing a single noun or adjective with a word that conveyed an opposite or incompatible meaning.

All passages were similar in length and each paragraph contained five sentences. Since the middle paragraph was of primary concern in the experiment, its structure was more carefully controlled across passages. The first and fourth sentences of the paragraph contained the main point and detail inconsistencies, respectively. Both of these sentences were 10 words in length and contained 19-21 syllables. The inconsistent words that appeared in the modified versions of the paragraphs were similar in number of letters and syllables to their consistent counterparts. The remaining three sentences contained 14-15 words each and had comparable numbers of syllables across passages.

In addition, the organizational structure of the middle paragraph was the same across passages. The opening sentence introduced the main topic of the paragraph, and the four subsequent sentences each provided a supporting point. Thus, in the main point inconsistency condition, the first sentence of the paragraph conflicted with all other sentences. The detail

inconsistency was embedded within a supporting point and was not in itself related to the topic sentence. It was always based on information contained in the immediately preceding sentence.

Insert Table 1 about here.

One of the paragraphs used in the experiment is presented in Table 1 in its consistent version with the words that were substituted in the inconsistent versions indicated in parentheses. The main idea inconsistency appears in the first sentence, where the economy is said to be characterized by poverty. But subsequent sentences describe positive aspects of the economy: control of the trade routes, successful industries, flourishing agriculture. The detail-level inconsistency is in the fourth sentence, where it is stated that the textile industry was government owned. But the previous sentence said that all of the industries were privately owned and operated. In order to notice either of these inconsistencies, a reader would need to integrate information across sentences. However, the statement of the main idea conflicted with virtually all of the other sentences in the paragraph, while the detail statement conflicted with only one.

Six multiple-choice questions were constructed for each passage, two based on each paragraph. Each question asked a subject to select an appropriate paraphrase of a segment of the text. The questions on the first and third paragraphs were included to prevent subjects from focusing exclusively on the middle paragraph and will not be considered further. One of the questions on the middle paragraph involved the main idea and the other

involved the detail. Each question had four alternatives, one of which was a paraphrase of the consistent version of the statement and another of the inconsistent (see Table 1 for examples). In addition, the option "cannot be answered on the basis of the paragraph" was provided for subjects who noticed the inconsistency and were unable or unwilling to resolve it.[1]

Design

The experimental design consisted of three within-subjects factors and one between-subjects factor. The within-subjects factors were passage (Inca, Moslem, and Byzantine), type of inconsistency (main point, detail, and none), and order in which a particular passage was read (first, second, or third). The between-subjects factor was whether or not subjects were alerted before reading that the passages contained inconsistencies. A Latin Square design was used for counterbalancing the three within-subjects factors. This design, described in Winer (1971, pp. 739-745), uses all 27 treatment combinations of a full 3^3 factorial, but each subject provides only three observations. Thus, each subject read each passage, but the order in which the passage was presented, and the type of disruption it contained, depended on to which of the nine presentation groups the subject was assigned.

Subjects in the experiment were 90 undergraduates enrolled in an educational psychology course at the University of Illinois. The majority

of the students were sophomores and juniors. It was found after the experiment was conducted that the data sets for three subjects (from different cells) had been lost. Since it was no longer possible to run additional subjects, and because the analysis of variance outlined by Winer requires equal cell size, the missing data were replaced by cell means.

Procedure

The entire experiment was controlled by the PLATO computer system.

Subjects were run in several large groups in a classroom containing 30 PLATO terminals, each with an alpha-numeric keyboard and a plasma display screen. An assistant was present during each session to instruct subjects how to sign onto the computer and to answer questions. As subjects signed on, they were automatically assigned to one of the 18 cells in the design according to a predetermined plan.

All instructions for the experiment were presented via computer. The instructions were displayed sentence by sentence, one paragraph to a "page" of screen. Each sentence appeared underneath the immediately preceding one so that, in effect, subjects read down the screen. The rationale of having the display position of sentences move down the screen was to provide a spatial cue for each sentence's position in the paragraph, thereby making it easier for subjects to re-expose a particular sentence. As each new sentence was presented, the previous one was erased. Subjects were instructed to initiate presentation of each sentence by pressing

a key labeled "NEXT." They were told they could look back at the preceding sentence by pressing a key labeled "BACK." They could reread the entire paragraph by pressing a key labeled "LAB," which took them directly back to the top of the screen and was more convenient than repeatedly pressing the BACK key. It was recommended that, in order to facilitate movement through the text, subjects use the three middle fingers of their right hand to press the NEXT, BACK, and LAB keys, respectively. The computer program provided subjects with ample opportunity to familiarize themselves with the various control keys and to practice moving through the text as they read the instructions.

Further instructions informed subjects that they would be reading passages dealing with topics in world history and that they should read them carefully in preparation for subsequent questions on their content. No mention was made of the fact that the amount of time spent on each sentence would be recorded. Half of the subjects received the following additional instructions:

> Some of the paragraphs that you will be reading contain inconsistent information, where ideas expressed in one sentence conflict with ideas expressed in one or more other sentences. Carefully evaluate the information in each paragraph for inconsistencies. Make a mental note of any conflicts or contradictions you detect. You will get questions about them later.

When subjects finished reading the instructions, they went on with the experiment at their own pace. The passages were presented in the same format as the instructions, one sentence at a time, one paragraph to a page. Subjects could reread each paragraph as often as they wished, but once they pressed the NEXT key to go on to the next paragraph, they could not return to a previous one. The warm-up passage was presented first, followed by the three experimental passages. After reading each passage, subjects answered the six multiple-choice questions by pressing the appropriately numbered key. The computer recorded the responses and the amount of time taken to respond.

When subjects had completed the reading and question-answering tasks, they were given instructions for the detection task. They were informed that inconsistencies had been present in some of the passages (for half of the subjects, this was actually a reminder) and that they would now be asked to identify them. They were shown the middle paragraph from each of the four passages, with the sentences numbered 1-5. Subjects were asked to indicate the number of the sentence they thought contained the inconsistency and to select "6" if they thought the paragraph did not contain an inconsistency. If subjects indicated that a confusion had been present, they were automatically branched to two additional questions: (a) Did the confusion involve a main idea or a detail? and (b) Did you notice the inconsistency during the initial reading of the passage? Upon completion of the detection task, a brief explanation of the purpose of the experiment was provided.

Results

This section of the paper is divided into three sections. The first section reports the data obtained from the two processing measures, exposure times and number of re-exposures of target sentences. The second section examines the responses and response times to the questions based on the main idea and detail target sentences. The final section describes the detection data and includes a brief report of a study carried out to validate the detection measure used in the present experiment. Consideration of the relationships among the dependent measures will be postponed until the Discussion section.

In order to eliminate redundancy, we will first make several general comments which pertain to all analyses. First, the order in which a particular passage was presented was entered into each analysis as a factor. Although one passage was presented as a warm-up passage, one might still expect to find changes in performance as subjects warmed up still further to the task and became more accustomed to moving around through the text, responding to comprehension questions, and searching for inconsistencies. Many of the analyses did, in fact, reveal a reliable effect of order which was undoubtedly due to such practice effects. However, the main effect of interest, type of inconsistency, was counterbalanced across order, and interactions involving order were either not reliable or were uninterpretable. To simplify exposition of the results, we will not report the order effects in the text. The

interested reader may consult Appendix A for a listing of all significant order effects and Appendix B for a discussion of the order effects and a listing of the cell means which show main effects of order and interactions of order with type of inconsistency.

Second, the passages which served as the experimental materials were entered into the analyses as fixed effects. Though we attempted to make the passages comparable on structural, thematic, and organizational factors, they did of necessity differ in specific content and, therefore, perhaps in familiarity and comprehensibility. Hence, it would not be surprising if the passages differed in the salience of their inconsistencies or in the difficulty of questions based on them. Several analyses showed reliable effects due to passage, but these effects will not be considered in the text for the same reasons mentioned in the preceding paragraph. (See Appendix A for a listing of reliable passage effects.)

Third, because instructing subjects to be on the alert for inconsistencies did not affect performance on any of the dependent measures, the analyses have been collapsed over the instruction factor. Preliminary analyses revealed that alerted subjects did not spend more time reading the passage or look back at critical sentences more often than unalerted subjects, nor were they more likely to notice the inconsistencies during reading. One possible reason for this lack of an effect of instructions is that the demand characteristics of the task were such that all subjects processed the text carefully in preparation for the test questions.

All data analyses follow Winer's Plan 11 analysis of variance for Latin Squares (1971, pp. 739-745) with order, passage, and type of disruption as within-subjects factors. Note that level of idea (main point vs. detail) does not appear as a factor in the design. Since these ideas involved qualitatively different kinds of information and appeared in different serial positions, we would not know to which of these differences an effect was attributable. Therefore, for each dependent measure, two separate analyses were carried out, one for the main idea and another for the detail. The question of primary interest is whether the type of inconsistency present in a passage (main point, detail, none) affected performance. For the main idea, the critical comparison was between the inconsistent main point condition and the two consistent main point conditions. For the detail, the comparison was between the inconsistent detail condition and the two consistent detail conditions.

When a reliable main effect of type of inconsistency was obtained, Fisher's lsd procedure was used to determine the locus of the effect. Unless otherwise noted, the two consistent conditions were always reliably different from the inconsistent condition and were not reliably different from one another. The rejection region for all statistical tests was $p < .05$.

Processing Measures

Exposure times. The computer automatically recorded the amount of time each sentence was exposed on the screen. Exposure time is not

necessarily synonymous with reading time, but it provides an indication of the amount of time spent reading, studying, or thinking about the sentence. Exposure times were obtained for every sentence in every passage, but the data of concern involve only the middle paragraph of the three experimental passages. There are a number of possible ways to analyze these data, but the dependent measure we adopted was the total amount of time a subject spent on the second and fourth sentences. The reason for focusing on the fourth sentence is obvious: It contains the word that is inconsistent with information provided in the third sentence. The reason for focusing on the second sentence may be less apparent because the first sentence actually contained the inconsistent information. However, there is no reason to expect differences in reading time until subjects read beyond the manipulated sentence and encounter conflicting information. An analysis of time spent on the first sentence supported this assumption. The reason for analyzing total exposure time is that pilot work revealed it to be a more appropriate measure than time on first exposure, given that individual subjects varied greatly in their approach to the task. Some read through the paragraph very rapidly, then went back to the beginning to read each sentence more slowly. Others spent a great deal of time on each sentence on their first and only exposure to it. Pilot work also indicated that time on the entire paragraph was not an appropriate measure because excessive variance was contributed by the other sentences in the paragraph.

Insert Table 2 about here.

The mean total exposure times on the main point and detail target sentences (sentences 2 and 4) are presented on the left side of Table 2, where it can be seen that our expectation of longer exposure times on inconsistent sentences was upheld. Analysis of variance of the main point exposure times yielded a reliable effect of type of inconsistency, such that subjects reading passages containing a main point inconsistency spent more time on the second sentence than subjects reading the passages containing either a detail inconsistency or none, $F(2,162) = 31.91$. The exposure time analysis for the detail target statement also revealed a reliable effect of inconsistency type, such that subjects encountering a detail inconsistency spent more time on the target sentence than did subjects not encountering a detail inconsistency, $F(2,162) = 25.78$. In addition, application of Fisher's lsd procedure indicated that subjects who encountered a main point inconsistency also spent more time on the detail statement than subjects reading normal versions of the passages, suggesting that the main point inconsistency led to slower reading of the entire paragraph. Though one may argue that the differences on the detail target sentence arose because the inconsistent word was somehow more difficult than the consistent word it replaced, this argument is untenable for the main point results. The difference due to a main point inconsistency appeared on subsequent sentences which were identical for all subjects.

Re-exposures of target sentences. The second on-line dependent measure was the number of times subjects initiated additional exposures of the target sentence after their first exposure to it. The question of interest is whether subjects were more likely to go back to the target sentence when it contained an inconsistency than when it did not. The right side of Table 2 shows the mean number of re-exposures of the main point and detail target sentences. The main point analysis yielded a reliable effect of type of inconsistency, $F(2,162) = 6.07$. Sentences involving inconsistent main points were re-exposed significantly more often than sentences involving consistent main points. The analysis for detail sentences failed to reveal a statistically reliable difference due to type of inconsistency, despite a trend in the expected direction, $F(2,162) = 2.33$, $p = .10$.

The analysis of re-exposures provides further evidence that subjects noticed the inconsistencies during reading, but it does not reveal what processing strategies were used. Were subjects more likely to reread the entire paragraph when they encountered an inconsistency or did they reread the previous sentence immediately after reading the inconsistent sentence? An effective monitoring strategy for subjects who noticed a problem would be to go back to the preceding sentence to verify that something was inconsistent.

In order to determine whether this strategy was used, the subjects' data records were examined for the following patterns of sentence exposure:

1,2,1 and 3,4,3. The number of subjects engaging in this strategy was low, but there were clear differences due to inconsistency condition. Upon exposure to a main point inconsistency, 31% of the subjects reread the initial sentence immediately after reading the second. In contrast, if the main point was consistent, only 7.5% of the subjects used this pattern of inspection. Similarly, 16% of the subjects encountering an inconsistent detail looked back at the preceding sentence, while only 6% of the subjects did so for a consistent detail. The apparent difference in the number of subjects who looked back at main point and detail inconsistencies is provocative, though it may well be an effect due to serial position in the paragraph.

Responses to Questions Based on Main Ideas and Details

Subjects' responses to the two multiple-choice questions of interest from each passage were categorized as belonging to one of four different response classes: (a) consistent--the alternative selected was compatible with the consistent version of the main idea or detail; (b) inconsistent--the alternative selected was compatible with the inconsistent version of the main idea or detail; (c) "can't answer"--the alternative selected stated that the question could not be answered on the basis of the paragraph; and (d) other--the alternative selected was one of the two distractor items. The proportion of responses falling into each of these categories for the main point and detail questions is presented in Table 3 as a function of the type of inconsistency present in the passage.

Insert Table 3 about here.

Analyses of the data summarized in line 1 of Table 3 revealed that "consistent" responses were less likely when the questions were based on inconsistent ideas than when they were based on consistent ideas ($F(2,162) = 61.03$ for main point questions; $F(2,162) = 45.41$ for detail questions). Such an outcome is hardly surprising, for a "consistent" response to a question based on inconsistent information would only occur if subjects had adopted the consistent interpretation, either by resolving the inconsistency or drawing an inference based on other information in the passage. Though about one-third of the subjects apparently did so, a comparable proportion of the responses fell into the "inconsistent" category. A subject might select the inconsistent alternative for either of two reasons: (a) he did not notice that the target statement conflicted with other information in the paragraph; or (b) he noticed the inconsistency, but, in compliance with the perceived task demands, he responded with the alternative that was compatible with the information he had read. Table 3 also shows that the "can't answer" option was selected somewhat more often when an inconsistency was present, but the difference in frequency was not reliable. This option was intended to provide the means for subjects to indicate they were aware of an inconsistency, but the wording may have been too vague for subjects to realize its intended use.

The variability in the responses to the questions based on inconsistent information suggests that comprehension of the material was disrupted. More compelling evidence, however, is provided by the response time data which are summarized in line 5 of Table 3. Analyses of variance were carried out on the amount of time required to answer the main point and detail questions, regardless of which response was selected. Subjects consistently required more time to answer both types of questions when they were based on inconsistent rather than consistent information, $F(2,162) = 10.55$ and $F(2,162) = 3.76$ for main point and detail questions, respectively.

Inconsistency Identification

In the last part of the experiment, subjects were provided with the middle paragraph of each passage and were asked to indicate which sentence, if any, contained an inconsistency. Responses were scored as correct identifications as follows: main point inconsistency, line 1; detail inconsistency, line 4; no inconsistency, line 6. Across all subjects and passages, approximately two-thirds of the line numbers were correct. As shown in Table 4, the proportion of identifications was similar across inconsistency conditions, and an analysis of variance confirmed that the differences were not statistically reliable ($F < 1$).

Insert Table 4 about here.

Validation study. Because the computer was not programmed to allow subjects to explain the nature of the inconsistency they detected, it is possible that some subjects who failed to give the appropriate line number actually did detect the inconsistency. It is also possible that some subjects who provided the appropriate line number did not pick up the inconsistency we intended to convey. In order to validate this measure of confusion detection, a second study was carried out.

In this study, 36 University of Maryland Baltimore County undergraduates were provided with the middle paragraph of each passage, typed on separate sheets of paper. The order of presentation was counterbalanced using the same Latin Square design described earlier. The subjects were informed that some of the paragraphs contained a fact that was inconsistent with other facts in the paragraph and that the inconsistency could involve either a main idea or a detail. The subjects were first asked to circle the line number of the sentence they thought contained an inconsistency, circling line 6 if no inconsistency was present. They were then asked to underline the word or phrase that was most inconsistent and to explain what it was about the sentence that made it inconsistent.

The proportion of correct identifications was first calculated only on the basis of the line numbers given. These data appear in line 2 of Table 4, where it can be seen that the detection rates for the main point and detail inconsistencies are similar to those of the main

experiment. However, subjects were much less likely to indicate that no inconsistencies were present in the consistent passages. The reason for this discrepancy is not clear; perhaps the demand characteristics of the task, in which written explanations were required, induced subjects to read more carefully and to use more stringent criteria for evaluating consistency. (Remember, too, that a different population of students was sampled.)

The verbal explanations were then examined for evidence that the intented inconsistencies had been identified. The detection rates based on these explanations, shown in line 3 of Table 4, are similar to those based on the line numbers. Of most importance is that, with only four exceptions, there was a perfect correspondence between the line number the subject indicated as containing the inconsistency and the verbal explanation. Therefore, we may conclude that the data from the original experiment do provide a sensitive index of inconsistency detection.

Self-reports of detection during reading. Returning now to a consideration of the original experiment, if a subject reported that an inconsistency was present, the computer program automatically branched to an additional question asking whether the inconsistency was noticed during the initial reading of the passage. Of those subjects who provided the correct line numbers for the main point inconsistency, 64% reported noticing it during reading. Similarly, of those subjects who

identified the line containing the detail inconsistency, 63% reported noticing it during reading. Though self-reports are often suspect, the fact that reading times and re-exposures of target sentences were affected by the presence of an inconsistency lends credence to the subjects' claims. More direct evidence of a relationship between these self-reports and processing behavior is provided by those subjects who adopted the strategy of immediately re-exposing the sentence involved in setting up the inconsistency (i.e., sentences 1 or 3). Of those subjects who used this inspection pattern and detected the main point inconsistency, 94% reported noticing the inconsistency during reading. Similarly, 92% of the detecting subjects who went back to the sentence preceding the detail inconsistency reported noticing the problem during reading.

The fact that the main point and detail inconsistencies were apparently equally salient to subjects during reading was somewhat surprising. However, a plausible explanation comes from responses to a second question asked of subjects who reported an inconsistency: Does the confusion involve a main idea or a detail? Considering only those subjects who provided the correct line numbers, 91% correctly identified the main idea inconsistencies as such, but 41% also classified the detail inconsistencies as main ideas. This suggests that subjects may have devoted equal attention to the main idea and detail statements because they considered them of equal importance. Another possibility is that by

virtue of the demand characteristics of the task, all information was processed to the same extent.

Discussion

The primary purpose of the present experiment was to obtain on-line evidence of comprehension monitoring during reading. To this end, the experiment was successful. Students spent more time on sentences containing inconsistencies, and they looked back at them more often than at consistent sentences. These modifications in processing provide compelling evidence that mature readers evaluate and regulate the success of their ongoing efforts to comprehend. The data also are consistent with current models of reading which view comprehension as an active constructive process (e.g., Just & Carpenter, 1980; Rumelhart, 1980). Recent empirical tests of such models have provided additional on-line evidence of changes in reading behavior. For example, readers return to previously read information and make regressive eye movements when they encounter pronouns whose referents are unclear (Carpenter & Just, 1977; Garrod & Sanford, 1977), and they require more time to read paragraphs which violate conventional organizational structure (Greeno & Noreen, 1974; Kieras, 1978).

The available evidence suggests that the construction of meaning typically proceeds smoothly and relatively automatically, but if a difficulty is experienced, the reader slows down and allocates extra attention to the problem area (Brown, 1980). The reader may deploy

debugging strategies such as making inferences, rereading, or jumping ahead in search of clarification. One of the strategies used for debugging purposes in the present experiment was the immediate re-exposure strategy discussed previously. After evaluating their understanding and finding it inadequate, subjects attempted to remediate the problem by checking to see if they had correctly understood the previous sentence. We must not conclude, however, that subjects who did not use this strategy were deficient in monitoring their comprehension. Rather, these subjects may still have had the propositions from the previous sentence stored in working memory (Kintsch & van Dijk, 1978), and so they checked memory instead of the text itself. An interesting empirical question emerges from the recent demonstration by Daneman and Carpenter (1980) that better readers have a larger working memory capacity than poorer readers. Perhaps it is only the less able readers who, upon encountering information that seems inconsistent, must physically reinstate the previous sentence for verification.

The fact that the majority of subjects were sensitive to inconsistent information suggests that they evaluated their understanding by testing whether the ideas expressed in the text were consistent with one another (Baker, 1979b). This internal consistency standard seems to be applied spontaneously given that instructions to evaluate the text for consistency did not differentially affect performance. There is also evidence that students use internal consistency at the expense of other appropriate evaluation criteria. For example, Baker (1979a) found that when

inappropriate logical connectives were introduced into expository passages, subjects did not identify them as confusions, but reported that the ideas expressed in the two clauses were inconsistent with one another.

While it may be true that evaluating text for consistency is the default standard for readers who are monitoring their comprehension, what of the students in the present study who did not identify the intended inconsistencies? Though we have argued that failure to report an inconsistency is not necessarily evidence of failure to monitor comprehension, the fact that one third of the college students in our sample failed to report the inconsistencies is troublesome. One could invoke Grice's (1975) cooperative principle to explain why students did not notice the disruptions during reading: They expected the writer to state only what was true, relevant, and unambiguous. However, we cannot explain the subsequent failures to provide the correct line numbers in terms of a violation of this contractual agreement between writers and readers because the students were explicitly informed that the "contract" had been violated.

Two alternative explanations are possible. Perhaps the nondetecting students were able to construct a consistent interpretation of the text, fitting the inconsistent information into what seemed to them a plausible schema (Collins et al., 1980; Rumelhart, 1980). But can we say that they actually comprehended the text? This seems instead to be a comprehension failure arising from misunderstanding; the reader feels satisfied with his

interpretation of the text, but it is not the one the author intended to convey.

Another possible reason why students did not report the intended inconsistencies is that they relied on a standard of external consistency; that is, they evaluated the information with respect to their prior knowledge. Support for this explanation is provided both in Baker (1979a) and in the validation study reported here. Many subjects who did not report the intended inconsistency did in fact report that specific information within the passage was inconsistent with what they believed to be true. For example, in the sample passage shown in Table 1, a number of subjects noted that Moslem society did not include serfs and poor peasants. This tendency to report conflicts with prior knowledge was particularly pronounced when the passages did not contain experimenter-introduced confusions. (Recall that only 29% of the subjects in the validation study correctly indicated that no inconsistencies were present.) This suggests that the first standard many students applied when evaluating the passages was one of internal consistency; if no internal inconsistency was found, they proceeded to test for external consistency. The nature of the criteria students apply when evaluating their comprehension warrants further investigation, especially in view of the evidence that there is a developmental shift from overreliance on external standards to effective use of internal standards (Markman, 1979; Osherson & Markman, 1975).

A secondary purpose of this study was to develop a profile of the successful comprehension monitor. We hoped to identify individuals who exhibited consistency in their processing of different passages and who successfully identified all inconsistencies. However, we found that only 16% of the subjects spent more time reading the inconsistent versions of both the main point and detail target sentences relative to the amount of time they spent on consistent target sentences. Efforts to identify consistent users of the immediate lookback strategy were also unsuccessful; only three subjects reread the sentences preceding the main point and detail targets when, and only when, the targets were inconsistent. Even with respect to confusion detection, only 25% of the subjects provided the correct line numbers for all three types of inconsistencies. In short, our attempt to characterize good comprehension monitoring in terms of individual consistency did not succeed.

Similarly, we were unable to discern systematic relationships between confusion identification and reading behavior. For example, subjects who spent more time on the inconsistent target sentences during reading were no more likely to provide the correct line numbers than those who did not. All we can say is that subjects who spent more time on the inconsistent sentences and provided the correct line numbers were more likely to report noticing the confusion during reading rather than after. (For the main point inconsistency, this was true for 23 of 30 subjects; for the detail inconsistency, 19 of 22.) Thus, increases in reading time reflect awareness of inconsistencies, but the

converse is not true; the absence of longer reading times does not indicate that subjects failed to notice the disruptions.

These results are analogous to Rothkopf and Billington's (1979) observation that, despite large individual differences in processing strategies during reading, subjects attained the same goals. The implication is that attempting to specify characteristics of the successful comprehension monitor is the wrong approach; there is no single most effective processing style. Readers have a wide variety of monitoring activities available to them, and these can be used with flexibility and effectiveness.

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Footnote

[1]The wording of this option was deliberately vague to avoid cluing subjects that inconsistencies were present. The wording, however, may have been too vague, since few subjects selected this option (see Table 3).

Table 1

Sample Paragraph and Questions

The early Moslem society is best characterized by great affluence (poverty[a]). The Moslems controlled the trade routes and had extensive trade throughout the known world. They also had many highly successful industries, all of which were privately owned and operated. The textile industry was especially wealthy due to independent (government[b]) ownership. Agriculture flourished, with a great variety of commodities produced by serfs and poor peasants.

Main Point Question	Detail Question
Early Moslem economy was	The textile industry was owned by
1. very poor.	1. the public sector.
2. highly successful.	2. the private sector.
3. stricken with bad management.	3. the church.
4. at the mercy of the sea winds.	4. the caliph.
5. cannot be answered on the basis of the paragraph.	5. Cannot be answered on the basis of the paragraph.

---

[a]Main point inconsistency

[b]Detail inconsistency

Table 2

Mean Total Exposure Times (sec)

and Number of Re-exposures of Target Sentences

Type Inconsistency	Exposure Time (sec)		Number of Re-exposures	
	Main Point Sentence	Detail Sentence	Main Point Sentence	Detail Sentence
Main Point	10.66	7.80	.90	.58
Detail	6.80	9.21	.51	.74
None	7.39	6.26	.57	.58

Table 3

Proportion of Responses in Each Category

and Response Times on Target Questions

	Question					
	Main Point			Detail		
	Type of Inconsistency			Type of Inconsistency		
	Main Point	Detail	None	Main Point	Detail	None
Response Category						
Consistent	.32	.80	.86	.79	.33	.82
Inconsistent	.41	.01	.01	.07	.44	.08
"Can't answer"	.16	.07	.10	.12	.18	.10
Other	.11	.12	.04	.03	.03	.00
Response Time (sec)	17.03	12.38	12.62	13.10	16.54	13.19

Table 4

Proportion of Correct Identifications of Inconsistencies

	Type of Inconsistency		
	Main Point	Detail	None
Main Experiment	.66	.62	.68
Validation Study			
Line Numbers	.74	.61	.27
Explanations	.79	.59	-

Appendix A

Summary of Significant Statistical Tests

Involving Order and Passage Effects

Reading Times

Main Point Sentences

Order: $F(2,162) = 7.24$

Passage: $F(2,162) = 5.79$

Detail Sentences

Order: $F(2,162) = 32.30$

Passage: $F(2,162) = 6.73$

Order X Passage: $F(2,162) = 3.39$

Order X Type of Inconsistency: $F(2,162) = 4.07$

Passage X Type of Inconsistency: $F(2,162) = 12.95$

Order X Passage X Type of Inconsistency: $F(2,162) = 14.49$

Number of Re-exposures

Detail Sentences

Order: $F(2,162) = 6.73$

Order X Passage X Type of Inconsistency: $F(2,162) = 3.05$

Proportion of Consistent Responses on Target Questions

Main Point Questions

Passage: $F(2,162) = 19.17$

Order X Type of Inconsistency: $F(2,162) = 4.30$

Detail Questions

Passage: $F(2,162) = 19.64$

Response Times on Target Questions

Main Point Questions

Order: $F(2,162) = 4.68$

Passage: $F(2,162) = 8.28$

Detail Questions

Passage: $F(2,162) = 5.38$

Identification of Inconsistencies

Order: $F(2,162) = 5.17$

Appendix B

Interpretations and Means of Order Effects

The purpose of this appendix is to support our claim that effects of order are essentially a result of greater familiarity with the computer equipment and task demands. As can be seen in Tables 1 through 4 below, subjects spent more time on target sentences in initial passages than in later passages, and they re-exposed the detail target sentences more often; they answered the comprehension questions more slowly at first; and the probability of identifying inconsistencies was lower.

There were two reliable interactions of order with type of inconsistency, and the cell means are shown in Tables 5 and 6 below. The detail exposure time interaction (Table 5) shows decreasing times with increasing order when inconsistencies were present but equally short exposure times across order when no disruptions were present. The main point question interaction (Table 6) is uninterpretable. The two triple interactions (not shown) are likewise uninterpretable.

Table 1

Exposure Times (sec) on Target Sentences

	First	Second	Third
Main Point Target	9.37	7.43	8.07
Detail Target	9.56	7.41	6.30

Table 2

Number of Re-Exposures of Detail Target

First	Second	Third
.78	.67	.46

Table 3

Response Times (sec) on Main Point Question

First	Second	Third
15.78	13.97	12.29

Table 4

Proportion of Correct Inconsistency Identifications

First	Second	Third
.63	.54	.78

Table 5

Exposure Times on Detail Targets as a

Function of Order and Type of Inconsistency

	First	Second	Third
Main Point	10.80	7.00	5.60
Detail	11.40	9.23	7.00
None	6.47	6.00	6.30

Table 6

Proportion of "Consistent" Responses on Main Point Questions as a Function of Order and Type of Inconsistency

	First	Second	Third
Main Point	.33	.33	.27
Detail	.80	.67	.90
None	.77	.93	.87

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